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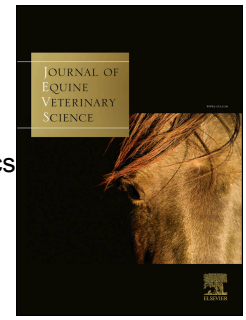

Feasibility of a Global Positioning System to assess the spatiotemporal characteristics of Polo performance

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Title

Feasibility of a Global Positioning System to assess the spatiotemporal characteristics of Polo performance

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Abstract

The implementation of global positioning systems (GPS) has become widely supported in a variety of sports, due to the insight it provides into athlete workloads, training parameters and playing styles. Despite widely reported use of GPS in equine settings, few studies have quantified the reliability of spatiotemporal characteristics in a dynamic environment of high intensity gameplay. Due to the unique game demands of Polo for both riders and horses, this study aimed to assess the inter-unit reliability between a traditional GPS placement between the shoulder blades and a Polo specific placement on players' belts, in order to inform the feasibility of GPS implementation within Polo. GPS data was collected across 37 unique rider - horse interactions. GPS metrics included distance covered, speeds attained and number of sprints performed. Data was further categorised into respect to equine specific speed zones. All metrics agreed across multiple reliability measures and were deemed qualitatively reliable (ICC>0.70 and CV<10%), with sprint count displaying 100% agreement between units. Findings suggest the spatiotemporal characteristics of Polo can be reliably measured via GPS through a traditional or belt-based placement, which leaves the decision of GPS placement at riders' discretion.

Keywords: Polo; GPS; Reliability; Feasibility

1. Introduction

Global positioning systems (GPS) are an established technological support system in team sports such as Australian Rules Football [1], Rugby [2,3], and Soccer [4]. Data collected via GPS can begin to characterise individual external work-loads which include speed and distance metrics, informing training parameters based on gameplay demands. Data may also be paired with supplementary findings from accelerometers, or measures of internal work-load from heart rate monitors, and subjective assessments such as rating of perceived exertion, to provide a comprehensive assessment of the load experienced by an athlete during exercise. In team sports, GPS may also have tactical or athlete management implications. For example the number of sprints performed by an athlete, or the number of collisions sustained when returning from injury may be limited. The accepted placement of GPS devices is within a customised vest that is worn by players, with the GPS unit housed between the shoulder blades. This placement ensures player safety, does not restrict movement and has been shown to produce reliable measures of spatiotemporal variables. Importantly, previous literature has also identified a reduction in reliability when higher velocities are achieved [5-7].

There is reported widespread use of GPS by equestrians and horse trainers [8]. However, there is minimal published work describing the use of GPS to inform equestrian training strategies [9]. Researchers have employed GPS technologies to assess maximum and average speed [7,10-13], or distance [11,13], with this data typically used in a descriptive manner. Equestrian sport encompasses a variety of disciplines, each with their own unique technical, tactical and spatiotemporal requirements. These factors mean successful equestrian performance is dependent upon the discipline being undertaken, but broadly speaking time to completion, technical mastery, or the scoring of more goals or points are common themes. As such, reporting of distances covered in tandem with the use of equine specific speed zones

would provide greater insight into the total external load upon a horse, and how this work is distributed throughout a performance.

Quantifying the external load placed upon equine athletes through GPS technology, especially in equestrian team sports such as Polo, may prove valuable in tournament settings where multiple horses require maximal performance across numerous games, over an extended time frame. Under Hurlingham Polo Association rules [14], riders are permitted to change horses within chukkas but must change horses between chukkas. This presents a unique data collection process with riders undertaking multiple interactions with numerous horses possibly within, and between chukkas.

A further advantage of GPS in Polo would be describing the spatiotemporal characteristics of each level of Polo played (as defined by cumulative player handicap); more information is required in this area as performance literature pertaining to Polo is limited to date [15-20]. By extension, Polo presents sport specific needs including rider movements, falls, collisions, contact through 'ride offs' and possible restrictions to players' shot selection if a traditional GPS positioning strategy is used. Hence, the aim of this study is to assess the inter-unit reliability between traditional and Polo specific GPS placements in quantifying spatiotemporal characteristics, in order to inform the feasibility of GPS implementation within Polo. It is hypothesised that spatiotemporal metrics will present a high level of inter-unit reliability between unit placements, with a likely reduction in reliability as velocity increases, as per previous investigations.

2. Methods

All procedures were approved by the Waikato Institute of Technology Ethics committee and carried out in accordance with the International Guiding Principles for Biomedical Research Involving Animals as issued by the Council for the International Organizations of Medical Sciences. Informed owner/player consent was also obtained.

2.1 Sample population

Ten Polo players (five females; five males; mean handicap: +1 goal), volunteered for this study. Players wore self-selected riding attire, with the exception of riding helmets, which were in accordance with Hurlingham Polo Association regulations [14]. Observations were recorded during practice chukkas, at the early part of the New Zealand Polo season (October - November). Each player rode between two and six horses, tallying 37 different horses and 37 chukkas. All horses were thoroughbred with at least one season of Polo playing experience and were a minimum of four years old. A total of 49% (18 horses) of observations were made during chukkas played upon a full pitch (150m x 275m), with the remaining 51% (19 horses) of observations made upon a pitch a third of full size. Pitch size was at the participants' discretion and was independent of research design.

2.2 Experimental protocol

The present investigation utilised VX Sport 350 GPS units (VX Sport, Wellington, New Zealand), sampling at 10 Hz, with a speed range of 0 - 60 km/h, in equestrian mode. VX Sport devices (VX Sport, Lower Hutt, New Zealand) have previously been reported as

reliable as assessed via coefficient of variation (CV; <5%), when analysis has been performed in intermittent activity [6].

To maintain consistent GPS protocols, units were turned on 20 – 30 min prior to the start of session recording to allow time for satellites to be located and a secure connection to multiple satellites established. Each player was fitted with one GPS unit in the traditional VX vest, and the other in a pouch fixed to the rider's belt (Figure 1). The belt pouch was secured with insulation tape to minimise potential oscillation of the unit during data collection and reduce the risk of type 1 error. This position was chosen due to reported differences in segmental rotations between the trunk and pelvis [21]. Each player wore both units for the duration of the session (4 - 6 chukkas), including when changing horses. Once training had finished, units were removed from both locations (back and belt) and turned off.

2.3 Data Processing and Analysis

Data was imported using specialist software as provided by the GPS manufacturer (VX Sport, Wellington, New Zealand). Data was trimmed to remove the initial satellite lock period, and the activity period was divided into chukkas. Speed zones were assigned following data collection to ensure data was relative to current fitness capabilities of horses and riders. Although a maximum speed of 60km/h is predetermined via the manufacturer's equestrian mode, a maximum speed of 40km/h was selected for data analysis purposes as this was the upper limit of speeds attained during data collection. Speed zones using in-built software thresholds were constructed as follows: Zone 1: 0 - 12.8km/h; Zone 2: 12.9 – 15.6km/h; Zone 3: 15.7 – 18.8km/h; Zone 4: 18.9 – 31.6km/h; Zone 5: 31.7 – 40km/h. Time (s) and distance covered (m) in each speed zone were selected as dependent variables of interest, with between unit agreement of the number of sprints (an acceleration >3m/s/s) at a given starting velocity also reported.

Data was then exported to Microsoft Excel and variables extracted for further analysis. Analyses between GPS positions were conducted using a customised spreadsheet [22] to assess reliability, as expressed by intraclass correlation coefficients (ICC) and CV. Data were considered reliable if ICC >0.70 and CV <10%}[23].

3. Results

All measurements obtained between GPS placements were deemed to be qualitatively reliable, having satisfied the criteria of ICC >0.70 and CV <10% [23] (Table 1). There was a range in time and distances covered per speed zone, as detailed in Table 1. Players accumulated the most time in speed zone 1, yet due to the low velocity and passive nature of this zone more distance was covered in zones 3 and 4 (Table 1).

Players accumulated the most distance in speed zone 4 (Table 1), however metrics assessed in speed zone 4 also showed the greatest standard deviations, suggesting a range of locomotor behaviours within this speed zone. There was little time spent and distance covered in the highest speed zone (zone 5), with units displaying high levels of agreement as per perfect ICC values at this speed range. All speed and distance measures were deemed qualitatively reliable [23], irrespective of speed zone (Table 1). The number of accelerations of >3m/s/s (sprint) were recorded per player, per chukka and displayed 100% agreement between units. This degree of corroboration was maintained irrespective of starting velocity and horse selection.

Table 1: Reliability of spatiotemporal characteristics as derived from GPS data in Polo horses, expressed by Zone (Z), per chukka. Raw values for Time (s) and Distance (m) are shown, alongside percent difference between outcome measures, reliability metrics (CV; ICC and accompanying 90% confidence intervals) and a written confirmation of reliability.

		Device 1			Device 2									
	Speed Zone	Mean		SD	Mean		SD	Δ%	CV	ICC	LB		UB	Reliable?
Time (s)	*1*	547.6	±	238.9	553.9	±	239.0	1.5	2.4%	1.00	1.00	to	1.00	Yes
	2	114.4	±	46.8	113.5	±	49.5	-2.0	6.6%	0.97	0.95	to	0.98	Yes
	3	210.1	±	98.6	200.3	±	89.3	-4.1	4.6%	0.99	0.98	to	0.99	Yes
	4	458.1	±	289.0	461.1	±	304.6	-0.2	8.6%	1.00	0.99	to	1.00	Yes
	5	20.4	±	24.3	20.4	±	24.1	-0.1	1.1%	1.00	1.00	to	1.00	Yes
Distance (m)	*1*	618.2	±	267.7	624.7	±	264.8	1.6	4.6%	0.99	0.99	to	1.00	Yes
	2	389.3	±	159.9	386.1	±	168.9	-2.0	6.5%	0.97	0.95	to	0.98	Yes
	3	859.7	±	405.3	819.5	±	366.0	-4.0	4.6%	0.99	0.97	to	0.99	Yes
	4	2444.2	±	1591.2	2470.2	±	1681.4	0.1	9.1%	1.00	0.99	to	1.00	Yes
	Z5	69.8	±	150.4	70.6	±	150.1	1.1	1.3%	1.00	1.00	to	1.00	Yes

4. Discussion

This study aimed to assess the inter-unit reliability between traditional and Polo specific GPS placements in quantifying spatiotemporal characteristics, in order to inform the feasibility of GPS implementation within Polo. The data was reliable across sprint and distance characteristics, irrespective of GPS unit placement suggesting that GPS units worn either between players' shoulders or mounted on players' belts are feasible methods to assess Polo performance. This statement is further supported by sprint count data which displayed complete agreement between positions. These findings partially refute our hypothesis and previous literature [5,6] that reliability would decrease as velocity increases, as units maintained high levels of reliability across all speed zones. This is likely due to the current study employing a more robust statistical approach requiring the attainment of a high ICC (>0.70) and a low CV (<10%) concomitantly, as opposed to previous studies [10,12] that employed a single measure of reliability such as linear regression, which may be inadvertently interpreted as a measure of prediction between variables. Further, a device with a higher sampling frequency (10Hz) than that of previous literature (0.2-1Hz [7,10,12,13]) was used. This device also had an equestrian mode to permit the calculation of five sport specific speed thresholds and appropriate upper tolerable speed limits (60 km/h).

To the best of the authors' knowledge this is the first paper to assess the reliability of GPS within a free-playing Polo setting. Previous literature has investigated the reliability of GPS enabled technologies in closed and controlled equine environments [12,13]. These studies took place on tracks of known distance and consisted of assessing single horse and rider dyad performance [7,10,12,13], with another study using GPS to assess the reliability of speeds attained at physiological landmarks [12]. Whilst often allowing for the simultaneous assessment of validity, these scenarios do not mimic the dynamic and potentially hazardous

environments of typical equine sporting pursuits [15]. Furthermore, despite these data being collected, evidence suggests there is little transfer from data acquisition to analysis or further interpretation [8]; highlighting a potential knowledge gap with respect to the potential value of GPS technology in equestrian sport [9].

Polo players are required to perform multi-planar movements consistently across a string of horses within games; as such the placement of GPS units to permit these unique movements whilst ensuring accurate monitoring of spatiotemporal characteristics is vital. Inter-unit measurements within this study replicate those of Johnston *et al.*, [5], who suggested that GPS presents a reliable method of assessing spatiotemporal characteristics at 10Hz in humans. Equine literature has reported reliability of GPS technology at low sampling frequencies (0.2-1Hz or not reported) when compared to other measures of speed over known distances [7,10,12,13]. The findings of the present study support previous results whilst adopting a higher sampling frequency and following a more rigorous statistical approach, that required the agreement of multiple analyses for a qualitative interpretation of reliability to be declared [23]. This is an important addition to the literature as it ensures that Polo practitioners (grooms, players, veterinarians etc.) can reliably record measures of external workload (speed and distance) utilising either a traditional or Polo specific GPS unit placement. Sprint count data showed 100% agreement between units suggesting that high-intensity and explosive movements can be reliably measured, independent of starting velocity, horse selection and unit position in early season chukkas. quantify in-game spatiotemporal characteristics that Polo horses are exposed to, allowing for training programmes to best replicate the demands of game play; ultimately, improving horse ability and welfare within the sport. This may also have tactical bearing upon the game with respect to horse playing order within a string, matching the string to the level of play (handicap) and how players distribute their strings' efforts in tournament settings.

5. Conclusion

Given the high inter-unit reliability of all spatiotemporal outcomes measured within this investigation, GPS units can be placed either at the traditional position between one's shoulder blades, or on the belt, if reliable and consistent measures are sought. The authors recommend that players consider their own comfort, playing style, collision rates and risk of falls as these may influence preferred GPS locations. Implementing GPS technology in a way that best benefits human and horse participants is recommended for the long-term athletic careers of both species of athlete [24].

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Figure captions:

Figure 1: Placement of GPS units as per the VX Sport vest (Left) or belt mounted pouch (right)

Highlights

- Polo presents unique movements by rider and horse that need to be reliability assessed to quantify game demands
- GPS units sampling at 10Hz can reliability capture speeds, time in speed zones, distance covered and sprint counts independent of GPS unit placement
- GPS placement is at the discretion of Polo players
- GPS can be used to reliably assess horse workload during chukkas or gameplay

Declarations of interest: The authors have no conflicts of interest to declare.

Ethical approval for this investigation was provided by two relevant committees; the Animal Ethics Group and the Human Experimental Research Group, both of the Waikato Institute of Technology (Wintec). These groups are established to ensure that research from the institution is in accordance with the International Guiding Principles for Biomedical Research Involving Animals as issued by the Council for the International Organizations of Medical Sciences, and the declaration of Helsinki, respectively.